March 15, 1894.

The LORD KELVIN, D.C.L., LL.D., President, in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read :—

I. "The Thermal Radiation from Sun Spots. Preliminary Notes of Observations made at Daramona, Streete, Co. Westmeath, 1893." By W. E. WILSON, M.R.I.A. Communicated by G. JOHNSTONE STONEY, F.R.S. Received January 4, 1894.

These observations were made by means of a large heliostat, lent by the Royal Society, and a Boys's radio-micrometer. The heliostat consists of a plane silver-on-glass mirror of 15 in. aperture. It is mounted equatorially, and driven by a clock. When in use, it is adjusted to reflect the sunlight to the north pole, and, as long as the driving clock is kept in motion, the beam of light remains fixed in that position. In the track of this beam, and about 12 ft. from the plane mirror, is mounted a concave silver-on-glass mirror of 9 in. aperture, and about 13 ft. focus. Its axis points to the south pole, so that the cone of rays formed by it strikes the centre of the plane mirror, and a short distance inside the focus. A small plane mirror mounted on the end of an arm is then so placed as to intercept the cone of rays, and reflect it horizontally into the observatory window; an achromatic lens enlarges the solar image which is formed on a screen in the room to 4 ft. in diameter.

Behind this screen, and standing on a pier of concrete, is mounted the radio-micrometer. The aperture through which radiant heat reaches the sensitive thermo-couple is a round hole drilled through a thick sheet of brass, and is only 1 mm. in diameter. A white card-board screen is placed in front of the brass one to cut off heat from falling on the latter, and is provided with a hole slightly larger. A beam of lime light is thrown on the mirror of the radio-micrometer, and reflected on to the scale in the usual way. The diagonal mirror of the heliostat is provided with slow motions in two directions, which are moved by long rods and Hook joints inside the observatory. Thus any part of the sun's disc can be placed on the small aperture

of the radio-micrometer, and the driving clock will then keep it there.

The observations are taken in the following manner. A small screen is placed over the aperture of the radio-micrometer, and the zero position of the spot of light on the scale noted. The screen is then removed, and the umbra of a sun spot placed on the aperture. The reading is then taken and entered in column u. The image is then moved, so that a part in the neighbourhood of the spot, but at *the same distance from the centre of the solar disc*, is placed on the aperture. This reading is entered in column N. Finally, a reading is taken at the centre of the disc, and entered in column C. The throws of the instrument are then got by subtracting the figures in columns u, N, and C from the zero. The deflections of the instrument have been experimentally proved to be *strictly proportional* to the amount of radiant heat falling on the thermo-couple. The following is a typical observation taken August 7, 1893, of a large sun spot then visible. The *umbra* of this spot measured 0·8 in. across on the screen, so that the aperture of the radio-micrometer was only covering about $\frac{1}{400}$ of the apparent area of the umbra.

Zero.	u.	N.	$u-z$.	$\mathrm{N}-z$.
15·8	17·1	20·4	1·3	4·6
15·6	16·9	20·2	1·3	4·6
15 5	16·8	19 9	1·3	4·4
15·3	16·7	19·8	1·4	4·5
15·2	16·6	19·6	1·4	4·4
15·1	16·4	19·5	1·3	4·4
14·9	16·1	19·4	1·2	4·5
		Means....	1·31	4·49

The ratio $\dfrac{\text{umbra of spot}}{\text{neighbouring photosphere}} = \dfrac{1{\cdot}31}{4{\cdot}49} = 0{\cdot}292.$

Five concordant readings gave a mean deflection of 4·57 for the centre of the sun, which gives for the ratio $\dfrac{\text{umbra}}{\text{centre}} = 0{\cdot}287.$

This spot was at a distance from the centre of the disc of about 0·4 of the radius.

As the radiation from the photosphere falls off from the centre to the edge of the disc, it seemed an interesting point to determine if any change in the ratio of u/C would take place as a spot was carried across the disc by the sun's rotation. If the spot is, as is generally thought, a depression, the absorption of heat ought to increase as it is carried towards the limb, on account of the increased

depth in the solar atmosphere through which the radiation would have to pass. On the other hand, if the spot was floating *above* the absorbing atmosphere the radiation from it would remain constant in any position on the solar disc.

The following is the value of the heat radiation from the photosphere taken along a radius of the sun, where 0 = centre and 100 the limb. The radiation R equals 100 at the centre.*

D.	R.
0	100·0
10	99·8
20	99·5
25	99·3
30	98·9
40	97·2
50	95·3
60	92·2
70	87·8
75	85·3
80	82·5
90	72·0
95	61·8
98	51·5
100	42·9

It will be seen by the following observations of spots, taken from August 5 to November 9, that there is distinct evidence that the radiation from the spot does not fall off as rapidly when near the limb as the neighbouring photosphere; in fact, the ratio u/C remains nearly constant, whereas the ratio u/N gets nearer unity as the spot approaches the limb. The spot observed on the 22nd of October is a good example, as the same spot was observed again on the 26th, 29th, and on the 30th, when it had reached within a distance, D, of 95 from the centre. It will be seen that on these four dates the ratio u/C was respectively 0·338, 0·360, 0·313, 0·356, whereas the ratio u/N was 0·349, 0·410, 0·706, 0·783.

Langley,† in 1874 and 1875, measured the radiation from sun spots. He used a thermo-pile and galvanometer, and obtained as the mean of his results a ratio of $0·54 \pm 0·05$.

His method was first to take a reading in the neighbourhood of the spot, but between it and the centre of the disc. He then took a reading in the umbra, and, finally, a third reading in the neighbourhood between the spot and the edge of the sun.

* "The Absorption of Heat in the Solar Atmosphere," by W. E. Wilson and A. A. Rambaut, 'Proceedings of the Royal Irish Academy,' 3rd series, vol. 2, No. 2.

† 'Monthly Notices,' vol. 37, No 1.

Date.	$\frac{u}{C}$.	$\frac{u}{N}$.	D.
1893.			
Aug. 5	0·370	0·427	60
7	0·287	0·292	40
8	0·286	0·323	50
8	0·339	0·377	40
8	0·418	0·512	90
14	0·364	0·373	50
19	0·368	0·375	50
Sept. 2	0·309	0·309	10
3	0·298	0·298	10
4	0·420	0·450	30
4	0·430	0·446	30
7	0·287	0·355	85
Oct. 1	0·398	0·401	30
1	0·489	0·570	80
22	0·338	0·349	52
26	0·360	0·410	40
29	0·313	0·706	90
30	0·356	0·783	95
Nov. 8	0·365	0·800	97
9	0·339	0·848	85

The mean of the two photospheric readings he used as a divisor for the umbral reading. He then says, "The decrement of heat as we approach the limb is, though not exactly, yet so very nearly, in the same ratio for photosphere and spots, that no correction is needed on this account for the present observations."

If Langley failed, through want of instrumental means, to notice the difference between the absorption in a spot and the photosphere near the limb, his method would make his umbral readings too high. The mean of twenty observations here equals 0·356, against Langley's 0·54. This is a serious difference, and, I think, can only be accounted for either by the use of superior instrumental means, or by a possible variation in the radiation of spots in different years of the sun spot cycle.

It is difficult to see how *too low* a value for umbral radiation could be got, whereas too high a one might be found by want of definition and trembling in the image, so that some of the penumbral radiation would reach the thermo-couple.